

# How to test vector nature of gravity

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The covariant scheme is proposed to couple gravity and electrodynamics in pseudo-Riemannian four-spaces with electromagnetic connections. Novel dynamics of the charged particle and electromagnetic dilation-compression of its proper time can be tested in non-relativistic experiments. The vector equations acknowledge unified photon waves without metric modulations of flat laboratory space.

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The common expectation for the forthcoming search [1] of gravitation waves is that gravity has a tensor nature and gravitational or metric waves ought to be quite different from vector electromagnetic waves. The unorthodox paradigm of curved three-space was successfully employed in the last century to explain the precise gravitational observations [2-3], but divorced electrodynamical and gravitational forces: electric charges do not disturb 3D geometry.

Nonetheless the similarity of Newton and Coulomb interactions may suggest a natural similarity or identity of gravitons and photons, which are responsible for these interactions. An alternative opportunity to explain gravitational observations is to keep flat three-space but to derive the pseudo-Riemannian four-interval from a nonlinear relation,  $ds^2 = [d\tau(ds)]^2 - \delta_{ij}dx^i dx^j$ . Only three-spaces  $x^i$  with constant curvature, including flat space with  $\gamma_{ij} = \delta_{ij}$ , are compatible with the well-tested conservation of a system three-momentum at all space points.

The present scheme is based on material states of different charged objects in their proper four-spaces  $x_K^\mu$  with different pseudo-Riemannian metrics. But evolution of material objects may be compared and observed within 3D intersections  $x_K^i = x^i$  of the proper four-spaces, because all sub-spaces  $x_K^i$  keep universal Euclidean geometry and may form laboratory three-space. Flat laboratory space  $x^i$  and a universal time interval  $dt = \pm|dx^0|$  are common for all extended particle-field objects, while any curved four-space  $x_N^\mu$  may be associated only with one selected object N. The accepted gravitation of the point charges in common curved four-space differs from the novel scheme, called vector electrogravity, where non-relativistic electrodynamic relations may be used to test gravitation of the extended charges and their point sources.

In order to prove joint roots for gravitational and electrodynamic fields one has to derive all variation equations in a joint vector form and test the derived dynamical equations in practice. Let all fields from external sources be based on the unified forming-up four-potentials  $a_{K\mu}$  and contribute jointly into the

proper tetrad of any selected object N,

$$e_{N\mu}^\alpha = \delta_\mu^\alpha + \delta^{\alpha o} \sqrt{1 - \delta_{ij} v_N^i v_N^j} U_\mu^{\neq N}, \quad (1)$$

where  $U_\mu^{\neq N}(x) = \sum_K^{\neq N} (-Gm_K + m_N^{-1} q_N q_K) a_{K\mu}$ . One may verify that the proper pseudo-Riemannian tensor,  $g_{\mu\nu}^N \equiv \eta_{\alpha\beta} e_{N\mu}^\alpha e_{N\nu}^\beta$ , has universal symmetry  $\gamma_{ij}^N \equiv g_{oi} g_{oj} g_{oo}^{-1} - g_{ij} = \delta_{ij}$ , that corresponds to flat 3D sub-space under arbitrary electromagnetic and gravitational fields.

The same external electromagnetic,  $A_\mu^{\neq N} \equiv \sum_K^{\neq N} q_K a_{K\mu}$ , and gravitational,  $B_\mu^{\neq N} \equiv -G \sum_K^{\neq N} m_K a_{K\mu}$ , fields determine the proper canonical four-momentum

$$P_{N\nu} \equiv m_N g_{\mu\nu}^N dx_N^\mu / ds_N = m_N \delta_\nu^\alpha V_\alpha + m_N U_\nu^{\neq N}, \quad (2)$$

where  $\delta_\mu^\alpha V_\alpha = \{\beta^{-1}, -\beta^{-1} v_i\}$ ,  $\beta = \beta_N = \sqrt{1 - \delta_{ij} v_N^i v_N^j}$ ,  $c = 1$ ,  $v^i = v_N^i = dx_N^i / d\tau_N$ ,  $ds_N^2 = d\tau_N^2 - \delta_{ij} dx_N^i dx_N^j$ .

The proper time rate  $d\tau_N = \beta^{-1} ds_N = \sqrt{g_{oo}^N} (dx_N^o - g_i^N dx_N^i) = (1 + \beta U_o^{\neq N}) dx_N^o + \beta U_i^{\neq N} dx_N^i = dx_N^o + \beta U_\mu^{\neq N} dx_N^\mu = dx_N^o + \beta^2 U_\mu^{\neq N} P_\mu^N m_N^{-1} d\tau_N$  depends on all external gravitational and electromagnetic fields,

$$\left( \frac{d\tau_N}{dt} \right)^2 = \left( \frac{1 + \beta(B_o^{\neq N} + m_N^{-1} q_N A_o^{\neq N})}{1 - \beta(B_i^{\neq N} + m_N^{-1} q_N A_o^{\neq N}) v_N^i} \right)^2. \quad (3)$$

The gravitational dilation of the proper time rate  $d\tau_N$  with respect to the laboratory time interval  $dt$  coincides for weak fields in (3) with the similar result of general relativity [2]. There are also observations [4-6] of electromagnetic time dilation-compression for charges. Vector electrogravity explains this time relativity by coupling gravity and electrodynamics in the "old" pseudo-Riemannian four-space, but with electromechanical connections, when

$$\begin{aligned} g_{oo} &= (1 + \beta U_o)^2, \quad g_{oi} = (1 + \beta U_o) \beta U_i, \quad g_{ij} = \beta^2 U_i U_j + \eta_{ij}, \\ g^i &= -g^{oi} = \gamma^{ij} g_j = g_i = -g_{oi} g_{oo}^{-1} = -U_i (\beta^{-1} + U_o)^{-1} \\ g^{oo} &= g_{oo}^{-1} - g_i g^i = (1 - \beta^2 U_i U_j \delta^{ij}) (1 + \beta U_o)^{-2}, \quad \gamma_{ij} = \gamma^{ij} = -g^{ij} = \delta_{ij} \\ P_\mu &= m \{ \beta^{-1} + U_o ; -\beta^{-1} v_i + U_i \} = m (\delta_\mu^\alpha V_\alpha + U_\mu) = g_{\mu\nu} P^\nu \\ P^\mu &= \{ m (\beta^{-1} + U_o) ; P^i \} = m \{ \beta^{-1} - (U_o + U_i v^i) (1 + \beta U_o)^{-1} ; \beta^{-1} v^i \} \\ P_\mu P^\mu &= g_{oo} (P^o - g_i P^i)^2 - \delta_{ij} P^i P^j = P_o^2 g_{oo}^{-1} - m^2 \beta^{-2} v^2 = m^2. \end{aligned} \quad (4)$$

Proper four-space  $x_N^\mu$ , metric tensor  $g_{\mu\nu}^N$ , time rate  $d\tau_N$  and four-interval  $ds_N \equiv \pm \sqrt{g_{\mu\nu}^N dx_N^\mu dx_N^\nu}$  may be introduced only for one selected object N and they do not coincide with similar proper functions of other objects. An ensemble of different charged and neutral objects may be described in common three-space exclusively due to universal geometry,  $\gamma_{ij}^K = \delta_{ij}$ , of all their three-intervals  $dl_K$ . There is no universal geometry for all four-intervals, and no one

rate  $d\tau_K$  can be used as a universal time interval for an ensemble of interacting elements. One may however employ the common time interval,  $dt \equiv \pm\sqrt{\gamma_{oo}^\kappa dx_K^o dx_K^o} = \pm\sqrt{\delta_{oo} dx_K^o dx_K^o} = \pm|dx^o|$ , which is appropriate for all matter,  $dt = |dx^o|$ , and antimatter,  $dt = -|dx^o|$ , due to the universal metric tensor  $\gamma_{oo}^\kappa = \delta_{oo}$  of flat one-dimensional proper intervals  $|dx_K^o|$ . Laboratory evolution of matter is three-dimensional because only the universal flat intervals,  $dt_K$  and  $dl_K$ , rather than the unique proper four-intervals  $ds_K$ , have a common sense for the total ensemble.

According to the tetrad (1) this proper four-space can take Euclidean metric in a local inertial reference system, where all external fields are absent or balanced,  $U_\mu^{\neq N}(x_N^\nu) = 0$ . The equivalency principle leads to the following relations,

$$\frac{DP_{N\mu}}{dt} = \frac{dx_N^\nu}{dt} \frac{\partial P_{N\mu}}{\partial x_N^\nu}, \quad (5)$$

for the charged object N in its proper four-space  $x_N^\nu$ . The novel geodesic relations and dynamics of charges under the canonical conservation  $P_{N\mu}P_N^\mu = m_N^2$  in arbitrary electromagnetic fields can be tested in experiments.

A new relation between  $ds_N^2 \equiv g_{\mu\nu}^N dx_N^\mu dx_N^\nu$ ,  $dl_N^2 \equiv \delta_{ij} dx_N^i dx_N^j$ , and  $dt_N^2 \equiv \delta_{oo} dx_N^o dx_N^o$  may be derived, due to (1), from the equality  $ds_N^2 \equiv (dx_N^o + \alpha_N ds_N)^2 + \delta_{ij} dx_N^i dx_N^j$ , where  $\alpha_N \equiv \beta U_\mu^{\neq N} P_{N\mu} m_N^{-1} \equiv (U_o^{\neq N} + U_i^{\neq N} v^i)/(1 + \beta U_o^{\neq N})$ . The pseudo-Riemannian four-interval for charged matter reads

$$ds^2(\alpha_N) \equiv \left( \frac{\alpha_N dx^o \pm \sqrt{(dx^o)^2 - dl^2(1 - \alpha_N^2)}}{(1 - \alpha_N^2)} \right)^2 \approx \frac{dt^2}{(1 - \alpha_N)^2} - \frac{dl^2}{(1 - \alpha_N)}, \quad (6)$$

when  $(1 - \alpha_N^2)dl^2/dt^2 \ll 1$ . Notice that there is no Schwarzschild's divergence in (6) because  $\alpha_N < 0$  for pure gravitational potentials.

The four-interval  $s_N(\alpha_N)$  depends on external gravitational and electromagnetic fields that can be verified in practice for both neutral and charged non-relativistic objects. Solutions of (6) with  $(-\alpha_N) = GM/r \ll 1$  can explain, for example, the measured planet perihelion precession under flat three-space.

One may verify from (4) or (1), that the metric tensor or its tetrad takes four field degrees of freedom due to the external four-potential  $U_\mu^{\neq N}$ . Thus, the Hilbert variation with respect to ten "independent" components of  $g_{\mu\nu}^N$  is not a well-defined procedure. There is no physical notion with ten degrees of freedom behind the metric tensor  $g_{\mu\nu}^N$ , which is not an independent proper variable because  $g_{\mu\nu}^N P_{N\mu} P_{N\nu} = \text{scalar}$ .

Due to the variation of the proper particle-field action  $S_N$ ,

$$\delta S_N = - \int dx^4 \sqrt{-g} T_N^{\mu\nu} \delta g_{\mu\nu}(P_{N\lambda}) = - \int dx^4 \sqrt{-g} T_N^{\mu\nu} \frac{\partial g_{\mu\nu}^N}{\partial e_{N\rho}^\alpha} \frac{\partial e_{N\rho}^\alpha}{\partial P_{N\lambda}} \delta P_{N\lambda}, \quad (7)$$

gravitation has to be rewritten in terms of four-vector contraction of the Hilbert energy tensor  $T_N^{\mu\nu}$ . A basic dynamic equation, which determines the forming-up

four-potential  $a_{N\mu}$ , takes a vector Maxwell-type form,  $T_N^{\mu\nu}P_{N\mu} = 0$ , when  $\delta S_N = 0$  in (7). Wave solutions of this four-vector equation correspond to photons, which are responsible for both gravitation and electromagnetic interactions.

By taking the proper action  $S_N = -\int \sqrt{-g}d^4x [P_{N\mu}i_N^\mu + (f_N^{\mu\nu}W_{\mu\nu}^N/16\pi)]$ , with  $i_N^\mu \equiv \int (dx_N^\mu/dp_N)(-g)^{-1/2}\delta^4(s_N)dp_N$ ,  $f_{\mu\nu}^N \equiv \nabla_\mu a_{N\nu} - \nabla_\nu a_{N\mu}$ , and  $W_{\mu\nu}^N \equiv \nabla_\mu P_{N\nu} - \nabla_\nu P_{N\mu}$ , one finds the proper energy tensor

$$T_N^{\mu\nu} = \frac{P_N^\mu I_N^\nu(x) + P_N^\nu I_N^\mu(x)}{2} + \frac{W_{N\rho\lambda}^{\mu\nu}(x)}{16\pi} [g_N^{\mu\nu} f_N^{\rho\lambda} - 2g_N^{\mu\rho} f_N^{\nu\lambda} - 2g_N^{\nu\rho} f_N^{\mu\lambda}], \quad (8)$$

where the Maxwell-type four-vector  $I_N^\mu \equiv i_N^\mu - (4\pi)^{-1}\nabla_\nu f_N^{\mu\nu}$  may be associated with both kind of the extended homogeneous charges,  $m_N$  and  $q_N$ , located on the proper light-cone  $s_N(x_N, \xi_N) = 0$ . Variations of the scalar action  $S_N$  with respect to three proper variables,  $x_N^\mu$ ,  $P_N^\mu$ , and  $a_{N\mu}$ , lead to a system of vector equations,  $\nabla_\mu T_N^{\mu\nu} = 0$ ,  $T_N^{\mu\nu}P_{N\mu} = 0$ , and  $\nabla_\mu W_N^{\mu\nu} = 0$ , respectively, which determines dynamics of one selected object N. The tensor Einstein-type relation,  $T_N^{\mu\nu} = 0$ , for all components of the symmetric energy tensor (8) appears in vector electrogravity only for potential (superfluid, gauge-invariant) states of the object without energy exchange and radiation, when  $W_{\mu\nu}^N = 0$  and  $I_N^\mu = 0$ .

Measurements of the electron beam bending by static Coulomb potential can be performed with high accuracy. These measurements could test the dynamic equations (4)-(6) and the basic relation  $P_{N\mu}P_N^\mu = m_N^2$  for canonical four-momentum. Electromagnetic dilation-compression of time (3) provides one more opportunity to test the developed double unification (particle with field, gravity with electromagnetism) in the laboratory.

Vector electrogravity operates only with flat three-space for both gravity and electrodynamics. The vector approach to gravitation suggests the unified nature of gravitational and electromagnetic radiation, associated with photon waves. These vector waves can modulate only the four-space metric tensor  $g_{\mu\nu}^N$ , but they are irrelevant to Euclidean metrics,  $\gamma_{ij}^N \equiv \delta_{ij}$ , of laboratory three-space under all possible experiments.

- [1] R. Weiss, *Rev. Mod. Phys.* **71**, S187 (1999).
- [2] C.W. Misner, K.S. Thorne, and J.A. Wheeler, *Gravitation* (San Francisco: Freeman, 1973).
- [3] C.M. Will, *Theory and experiment in gravitational physics* (Cambridge: Cambridge University Press, 1993), revised ed.
- [4] E.J. Saxl, *Nature* **203**, 136 (1964).
- [5] M.A. Tamers, *Nature* **339**, 588 (1989).
- [6] W.A. Barker, *US Patent* No 5,076,971 (1991).